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ABSTRACT

This paper addresses two distinctive issues concerning animistic and anthropomorphic thought in the context of constructivist science education. The first concerns the extent of such ways of thinking, both within science itself and within school science. The second concerns the implications of this for theories of instruction in science education. The first section briefly considers the historical perspective of the exorcism of anthropomorphism from science. The second examines a variety of research into youngsters' animism and anthropomorphism, exploring data from school science students in particular. The third looks at the way science is presented in school, the potential for the positive use of anthropomorphic explanation and in the fourth considers some of the ways in which it might proceed given the arguments that have been made. The final section attempts to summarize the discussion. (KR)

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An instructional 'man-trap': anthropomorphic and animistic thought in constructivist science education.

A paper by **Mike Watts**, Roehampton Institute, London and **Di Bentley**, Buckinghamshire County Council.

To be presented to the symposium 'Research on Conceptual Change: Issues and trends'; American Education Research Association Annual Conference, Chicago, 1991.

ED336269

This vital fluid, through unnumbered tubes
Poured by the heart and to the heart again
Refunded; scourged for ever round and round;
Enraged with heat and toil, at last forgets
Its balmy nature; virulent and thin
It grows; and now, but that a thousand gates
Are open to its flight, it would destroy
The parts it cherished and repaired before.

Dr John Armstrong (1709 - 1779)
From the Art of Preserving Health Book II - The Blood.

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Objectives.

This paper addresses two distinctive issues concerning animistic and anthropomorphic thought in the context of constructivist science education. The first concerns the extent of such ways of thinking, both within science itself and within school science. The second concerns the implications of this for theories of instruction in science education.

0. Introduction.

Perhaps it does not matter at all. If a student of physics has a view that Aristotelian forces are at work on a projectile in mid air then instructional life continues almost unabated. Constructivist physicists nod knowingly, talk about pre-conceptions or alternative constructions and begin the process of exploring the students´ ideas in order to start where s(he) is at. They build bridges, design interventions or construct stepping stones to ´facilitate´ the student towards the ´scientist´s science´ of Newton et al.

If the student draws on a range of ideas to explain the distribution of air in a partially evacuated flask, the constructivist chemist barely breaks stride. More bridges and steps intervene to wean the youngster towards a particulate model of gases and elementary kinetic theory.

What happens, on the other hand, when the same youth suggests that a flame is alive, that clouds are living, mother Earth is suffering mankind´s incursions, particles ´want´ to move apart, magnetic poles ´like´ (or hate) each other, is revealing. No steps, no stones, no bridges. There are roughly two constructivist camps of thought: ´ignore

it and they'll grow out of it' or 'carry on teaching it as if it were true'.

The animistic flavour of young people's accounts in school science stands in sharp contrast to the supposedly neutral stance of science itself. Within the precise causal rationale of physics, for example, animistic interpretations of phenomena are completely discounted. Whether or not science itself is indeed entirely free of anthropomorphism remains a separate debate. This paper is not so much concerned with whether nature is endowed with vitalistic forces but, rather, quite what to make of the animistic and anthropomorphic responses provided by young people as they discuss phenomena within the classroom.

And herein lies the constructivist rub - animism and anthropomorphism is **exactly where many students are at but - either because these ideas are** so pervasive or useful - we choose - certainly within science education within the UK - to play on/with them and not 'correct' them perhaps in the mistaken belief that students will 'grow out of them'.

Here, the discussion is presented as follows. The first section briefly considers the historical perspective of the exorcism of anthropomorphism from science. The second examines a variety of research into youngsters' animism and anthropomorphism, exploring recent data from school science students in particular. The third looks at the way science is presented in schools, the potential for the positive use of anthropomorphic explanation and in the fourth considers some of the ways in which it might proceed given the arguments that have been made. The final section attempts to summarise the discussion.

1. Science and 'natural' philosophising.

Physics, alongside mathematics, is often seen as the traditional pinnacle of objectivity. Schrodinger (1966), for example, says:

> From all physical research the subjective intrusion of the researcher is rigorously barred so that the purely objective truth about innanimate nature may be arrived at. Once this truth is finally stated it can be put to the test of experiment by anybody and everybody all the world over, and always to the same result. Thus far Physics is entirely independent of the human temperemen.... Some of the champions of Physical Science go so far as to postulate that not only must the individual human mind be ruled out in the ultimate statements of physical research, but the human aspect as a whole must be excluded. Every degree of anthropomorphism is rigorously shut out; so that at least in this branch of science man would no longer be the measure of all things...

In the early history of natural philosophising and exploration, nature was seen as living and life-giving. Schrodinger (op cit) continues by suggesting that

> The image of nature which primitive man formed for himself emerged automatically, as it were, from the surrounding conditions, being determined by the biological situation, the necessity of bodily sustenance within the environment, and the whole interplay between bodily life and its vicissitudes on the one hand and the natural environment on the other.....the origin of science being without any doubt the very anthropomorphic necessity of man´s struggle for life.

The Aristotelian approach, for example, saw nature as essentially organic, a world view which continued for centuries. As Easlea (1983) points out, even Bacon (referred to as the Patriarc of Experimental Science) used a wide range of metaphors in his writing, none so consistently as the portrayal of nature as living - and specifically as female. Bacon extols his fellow colleagues, for example, to penetrate deeply the secrets of female nature, and gain power over her.

Easlea sees the end of this clearly anthropomorphic era with the writing of Descartes who claimed that the cosmos consisted only of unextended, immaterial (human) minds and an infinite universe of matter characterised only by the size, shape, and velocity of its constituent parts. He says:

> Truly with one gigantic intellectual blow Descartes had cognitively destroyed all non human life in the cosmos; he and his followers had, in the relevant words of the historian of science R.S.Westfall, ´banished life itself from the universe´.

Jaques Monod, the philosopher scientist, also argued that

> 'the cornerstone of the scientific method is the postulate that nature is objective'.

People who thought otherwise, those who invested nature with some element of vitalism, Monod calls animists. Animism, he says, establishes

> 'a covenant between nature and man, a profound alliance outside of which seems to stretch only terrifying solitude'.

Correct science, then, is the science of the mechanistic, the objective, the causal. And let's make no bones about it, against the full sweep of scientific certainty, animistic explanations for natural phenomena are **wrong**, and need to be corrected.

It is here, however, that science education suffers qualms of conscience. Both teachers and pupils find animistic and anthropomorphic explanations far too powerful and useful to discard. As aids to learning teachers use them to assist explanation and therby understanding. Pupils use them to make sense of the physical world in terms of their own experience. And why not? Isn't that precisely what constructivist theories of learning are all about? Students' science may not be orthodox but it is full of explanatory power. The problem may be different for teachers however. One could argue that teachers should be presenting the orthodoxy to students in order to challenge their own unorthodox science. How then can making use of anthropomorphic explanations be considered a helpful strategy for teachers? As Solomon (1980) points out of classroom explanantions in science:

> It may well be impossible to foretell what contributions will be made to (classroom) discussion (by students) but these may well include hopelessly 'wrong' approaches to the problem, full of childish animistic ways of thinking which are just as valuable for us to hear as the confidently causal ones. The young child's world is rich with feeling that no one would wish to destroy by sarcastic contradiction, but which must be augmented within the laboatory by more mechanistic imagination.

2. Post Piaget: Childrens' anthropomorphism.

More than fifty years ago Piaget (1929) described children's animistic thinking in some detail. To Piaget, animism refers to the tendency for children to ascribe life to inanimate objects. Anthropomorphism refers to the tendency to ascribe not only life, but also human characteristics to objects.

In 'The Child's Conception of the World' (1929) he wrote about the response patterns he saw in children's descriptions of the world. In a later book ('The Child's Conception of Physical Causality', 1930) he dealt at length with their conceptions of 'force' and says

> 'the child fills the world with spontaneous movement and living forces, the heavenly bodies may rest or move as they please, clouds make wind by themselves, waves raise themselves, trees swing their branches spontaneously to make a breeze, water flows by virtue of a force residing within it'.

He suggests that children see movement as caused by forces, and forces in turn explained by a bi-polarity between internal and external motives. All movement would seem to have both a cause and an aim, an external influence and an internal purpose.

There are two interesting points to be drawn from his work. First, he grants youngsters' conceptions a quality of acceptability, coherence and integrity that lends to them the merit of detailed consideration. Second, he weaves such animistic responses into his stage theory of conceptual development. For Piaget, such responses occur in the early stages of development, in the realm of pre-operational thought, roughly in an age-band of between 5 to 8 year old.

So, for example, Bettleheim (1976) echoes Piaget and notes that:

> To the eight-year-old (to quote Piaget's examples) the sun is alive because it gives light (and one may add that it does that because it wants to). To the child's animistic mind the stone is alive because it can move as it rolls down a hill. Even a 12 and-a-half year-old is convinced that a stream is alive and has will because the water is flowing.

He continues by saying that realistic explanations are usually incomprehensible to children because they lack the abstract understanding required to make sense of them.

Post Piaget, youngsters' explanatory responses for a varity of scientific phenomena have been the subject of much research. In some cases their explanations are treated in terms of their linguistic content so that they are analysed, for example, by word counts in order to measure vocabulary extension and the like (see for example, Cassells and Johnson 1985). On other occasions responses are considered against a normative frame of examination 'right' and 'wrongs', or towards a description of national levels of performance (as monitored in the UK, for example, by the government's Assessment of Performance Unit). More recently a body of research work has been accumulating where student responses are treated as explanatory domains in their own right (collected, for example, in bibliographies like Driver, Watts et al, 1990).

Constructivists in the Piagetian mould, then, will see animism and anthropomorphism as a stage, a period of childish thought that will be overtaken as more sophisticated and abstract structures come into play, as egocentricism withers and logico-mathematical thinking flowers.

But is that the case? There are reasons for arguing that not only do animistic explanations not diminish with age, but that there are strong reasons why they would survive intact into adulthood. Indeed several of the research papers in Driver and Watts (op cit) refer to numerour exampes of such explanations, well beyond the stages which Piaget would have charted.

language.

The idea that linguistic forms determine psychological structures (the Sapir-Whorf hypothesis) is now widely agreed to be too simplistic. If, as some suggest, animistic thinking is written through our language, it can come as no suprise that it permeates the explanatory language youngsters use. Could it be, for example, that some words simply carry with them the expectation or connotation of 'living' and that they are used carelessly or unwittingly? Like 'moving', 'dancing', and that adults begin to shed this connotation for some words and youngsters still have to do that? Like 'strong'. As Mathews (1980) says

> "Strong" is a strong word, but not because it means strong. In addition to being a strong word, it has an incredibly complex array of meanings and applications. Among the many things that may correctly be said to be strong are oxen, weightlifters, sunlight, colours, tea, arguments, convictions, customs, markets in certain commodities, irregular verbs, and ocean tides.'

Whilst language and its pervasive power is a useful hook for looking at anthropomorphic explanations, we believe that a more issue lies at the root of why those explanations are so explanatory, so persuasive. Why do they assist students in learning and understanding science? Why do teachers find them such a useful tool? We believe the nature of science itself is the key to this.

Our focus so far has been on the mismatch between animistic and anthropomorphic explanations used in science and scientific orthodoxy. An anthropomorphic explanation is not 'what really happens' However, given that science is a social construction, the notion of 'what really happens' is a changeable feast. Our historical perspective explored the development of science as an objective, causal and mechanisitic study in which animism as an explanatory framework was clearly not an enabling one. However, such a picture of science may well be far from the truth

for a multitude of budding scientists. If science itself were not an objective mechanistic causal set of relationships, but was alive, animate and espoused relationships of a different kind, what power would anthropomorphic explanation have then!

We have written elsewhere about the nature of science and its overt masculinity, (Bentley and Watts 1986) painting a different picture of science from the one above. In our terms, the science is masculine. Its very objectivity and causality relates to a understanding of the world in keeping with male experience but not - and here is the rub for 50% of the population of potential scientists - with that of women. Indeed, the very masculinity of science is at odds with the interpretation that women place upon phenomena and out of keeping with their early experiences. We would see explanations of the world in animistic and anthropomorphic terms as being much more in keeping with how women experience the world in general. If this is the case, perhaps female students make greater use of such explanations. Our research in the next section has some contribution to make to this argument.

First, however, before detailing our research, we need to explain our view of science that would be more amicable to anthropomorphic explanations. We start with the issue of relationships - not causal but more all embracing. A delicate balance. Gilligan (1982) feels that relationships, as viewed by women, are based not upon hierarchies (a very masculine approach) but rather as webs:

> the power of the images of hierarchy and web, their evocation of feelings, signifies the embeddedness of both of these images in the cycle of human life. The experiences of inequality and interconnection, then give rise to the ethics of justice and care, the ideals of human relationship - the vision that self and others will be treated as of equal worth, that despite differences in power, things will be fair; the vision that everyone will be responded to and included, that no-one will be left alone and hurt.

Whilst the words describe human emotions, the experiences upon which they draw are, Gilligan tells us, much more those of women than of men.

Thus women's early thinking leads them into an expectation that relationships exist which are multi-faceted and interconnected. The reductionism to a few pertinent variables for investigation is difficult for women - as difficult as the separation of behaviour from emotion, since it is at direct odds with their early experiences. Women expect all things to be interconnected by nature of the psychology of their development.

Science itself may or may not operate in terms of either webs or hierarchies, but the dominant image of science is one of competition - of scientists driving to be 'first' with the most ideal or correct solution, of challenge and repudiation. A science based upon the ideas of relationships between phenomena as being a connected web would present a very different picture. The reductionism would become much less viable and a greater range of variables would be taken into account. Thus a science in which emotions were attributed to behaviour - of atoms, molecules, forces, would make more sense for women and be a movement towards a less masculine, more feminist science.

Another of the features of a masculine science is the heavy emphasis it places on objectivity. It is precisely this objectivity that is so at odds with anthropomorphic and animistic explanations of science. What if science were not so objective and there were a place for subjectivity and methodologies which embraced the intuitive and humanly experiential? Several feminist writers and women scientists have espoused such a view, for example, Callaway (1981), MacKinnon (1981) and Fox Keller (1983). Goodfield (1981) rather neatly describes the reward of scientific enquiry as being one that embodies the feeling that 'one has touched something central to another person or to a subject'.

Such feminist scientific enquiry implies that understanding is not achieved by remaining outside events and being objectively detached. Rather it can only be achieved by including the event or object and

becoming a part of it. Thus emotions and feelings about events become a legitimate part of investigative science. Fox Keller in particular employs a very persuasive as well as an anthropomorphic argument for the inclusion of subjectivity on scientific investigation.

> (envisaging) science as personal.... adds to our thinking about science the kind of thinking that is often said to be 'just like a woman'. The unique contribution feminism makes to more traditional studies of science is the use of that expertise that has traditionally belonged to women - not simply as a woman's perspective - but as a critical instrument.(our parentheses)

Our premise then is that encouraging animism and anthropomorphism as explanations of scientific events may assist the understanding of women in particular - in other words, probably few people, but certainly women do not 'grow out of' such explanations towards a more objective way of explaining the world. Further, it may encourage the growth of a science in which the needs of - for example the planet - were taken into account as a matter of course and investigative science all the better for it. We use some examples from our research with seven year olds to illustrate our point.

Example 1.

A group of 8 year old childern were asked to investigate floating and sinking of objects in a bowl of water. After they had sorted the objects into groups of 'floaters' and 'sinkers', the teacher asked them to say why they thought some floated and others didn't. Several explanations linked weight to the observation. Melanie, Paul and Hayley however had different views.

Melanie: "those ones that float are not good swimmers - they feel safer near the top of the water.

I: Do you think the toy can swim then?

Melanie: No of course not, not like we can, it's got no legs and arms to

move with, but it still feels safer near the top - I´m just saying it´s like us when we first learn to swim.

I: So the toy doesn´t really feel safe - its just an example you´re using?

Melanie: Yes the toy does feel safe. That´s why it comes back up when you push it down. You can´t make it stay on the bottom, look (pushes toy down) because it knows its not safe there.

Paul: well, its like being older really. The older ones can handle themselves better so they can go to the bottom. The younger ones are not so good so they stay on top.

I: What do you mean ´handle themselves better´?

Paul: they know more. They can deal with the water without anything happening to them. Also they´re heavier, so they find it more difficult to get off the bottom.

I: Are they heavier because they´re older?

Paul: they could be. Older people usually get fatter when they´re old don´t they?

Hayley: The water can´t hold them up because they´re heavy, so they sink.

I: how does the water hold up the ones that float?

Hayley: It´s strong, so it pushes away everything that gets into it. You know - like its hard to walk through water in the swmming pool - it sort of pushes you away. So it knows when something is´t heavy and it tries to push it out. Look.. the white one (polystyrene) is getting pushed out most. The water knows this is the lightest so it tries to push it right out.

The explanations were:

a. the objects feel safe/not safe depending on their position in the water

b. age is connected with wisdom and size - even for objects

c. the water is strong and doesn't like objects invading it, so it pushes them away

Hayley's explanation is probably closest to 'reality' in terms of a scientific explanation. All three children assume knowledge and intent on behalf of objects or water. Traditionally, teachers would phrase questions - much as the interviewer did - to help pupils realise that water and objects such as toys did not have feelings or intentions. Indeed, the teacher did encourage some re-thinking by pupils along these lines. Suppose however that these explanations had been used as a mechanism for progressing towards a different kind of science. Hayley's idea of water 'not liking things to be in it' could be used as a direct link into the things that water did like to be in it and permitted or supported, such as animal life, plants etc, and notions of networks, food chains and their interdependence made sense of in terms of Hayley's explanations. Issues of pollution would arise easily from her own statements and be in keeping with her own ideas as well as her experiences as a women, that eveything is interconnected.

Paul's and Melanie's explanations are more difficult. They deal basically with ideas of security. 'handling themselves better due to age' and 'feeling safer when nearer the surface'. Feeling safer could be developed as a notion, by relating size and density to notions of safety. Explanations about size and density could then be used to draw children towards notions of forces in water and thus an explanation of why things float and sink in physical terms and well as the emotional feelings associated with safety.

Example 2.

A group of youngsters were working on ideas about breathing. They counted how many times they breathed in a minute, compared it to the teacher´s breating rate, compared it after they had run round the playground and finally were asked to observe some other familiar objects to see if they were breating and why they thought so.

Jennifer thought plants were not breathing. They didn´t move when she watched they and they had no chest. Paul said "Plants have feelings though. Prince Charles talked to his plants and played them music. They liked it"

Jennifer "How do you know?"

Paul "He said they did. He said they enjoyed different kinds of music and grew bigger and healthier"

Jennifer "How can they have feelings? If they´re not breathing they´re dead"

Paul "Why?"

"Because you need to breathe otherwise you´re dead"

Paul "Perhaps this plant is dead and that´s why we can´t see it breathing."

Jennifer "No plants breathe. Where are their lungs?"

Paul "Under the ground"

(The plant was dug up from its pot at this point. Jennifer remained unconvinced)

Leanne on the other hand could see the candle breathing.

"It flickers in and out when it breathes. So it´s alive."

I "Does it grow?"

Leanne "Yes, when you first light it, it's a little flame, then it gets

bigger".

I "What happens when the flame goes out?"

Leanne "It´s dead - or asleep".

I. "It´s still now, does that mean it´s not breathing?

Leanne "I don´t know, but it needs that thing to breathe like we do, or else it dies"

I "Oxygen?"

Leanne "Yes - the fireman who came to school said flames feed on oxygen, so if you want to put a fire out, you starve it of oxygen. A candle´s a flame, so it must feed on oxygen too. Like we need oxygen to breathe.

There are several examples of animism from all these 7 year olds. Leanne has made clear links between the needs of humans to eat and breathe and those of flames to eat and breathe. Whilst some of the evidence will not support her theories, she is not willing to abandon them. Paul is convinced that plants have feelings and presumably ears! Prince Charles appears to be similarly convinced of the emotions of plants and their capacity to experience music. Jennifer, despite her being unconvinced is still operating from an explanation based upon humans. Plants -like us- need lungs and a chest to breathe.

There has been a considerable amount of research into children´s understandings of what life and living mean. (Beveridge and Davies, 1983, Tamir et al 1981, Stead (now Bell) 1980). Our examples follow the trend. There is no significant difference between boys and girls in the degree of their animistic or anthropomorphic explanations, reported in other studies generally, or indeed in our findings. Only Tamir et al describe any small significance between the performance of girls and boys in ascribing objects to living and non-living categories. Boys ´get it right´ more frequently. Like other studies, we also found that

anthropomorphic explanations were present in older children, but less frequently. 14 year olds, learning about fuses, showed some interesting explanations, but in terms of anthropomorphism, the number of these explanations has fallen - the selection below is typical of the group.

"They just get hot and disintegrate" (Carl)

"They melt because there is too much electricity. It causes the wire to bend and it melts" (Steven)

"The electricity is moving too fast, it´s like scortching the wire so it burns" (Susan)

"its so that when the electricity is coming along fast- there is a lot of it - it gets excitied and the fuse melts because it´s excited" (Kim)

Only Kim´s could be seen to be an anthropomorphic description.

Teachers´ use of anthropomorphism.

As a mechanism for enabling learning, teachers - in particular secondary school science teachers - use such explanatory frameworks a great deal. So too do texts, as the examples below illustrate.

Lead oxide is a yellow powder. Scientists have discovered that there is one lead atom for every oxygen atom in lead oxide, and that the lead atoms and oxygen atoms are joined.
WE'RE CARBON - THE OXYGEN SEARCHERS
To reduce lead oxide to pure lead, ... is to find a way of separating the two different kinds of atoms. This is where carbon, the oxygen grabber, comes in.

Fig 1

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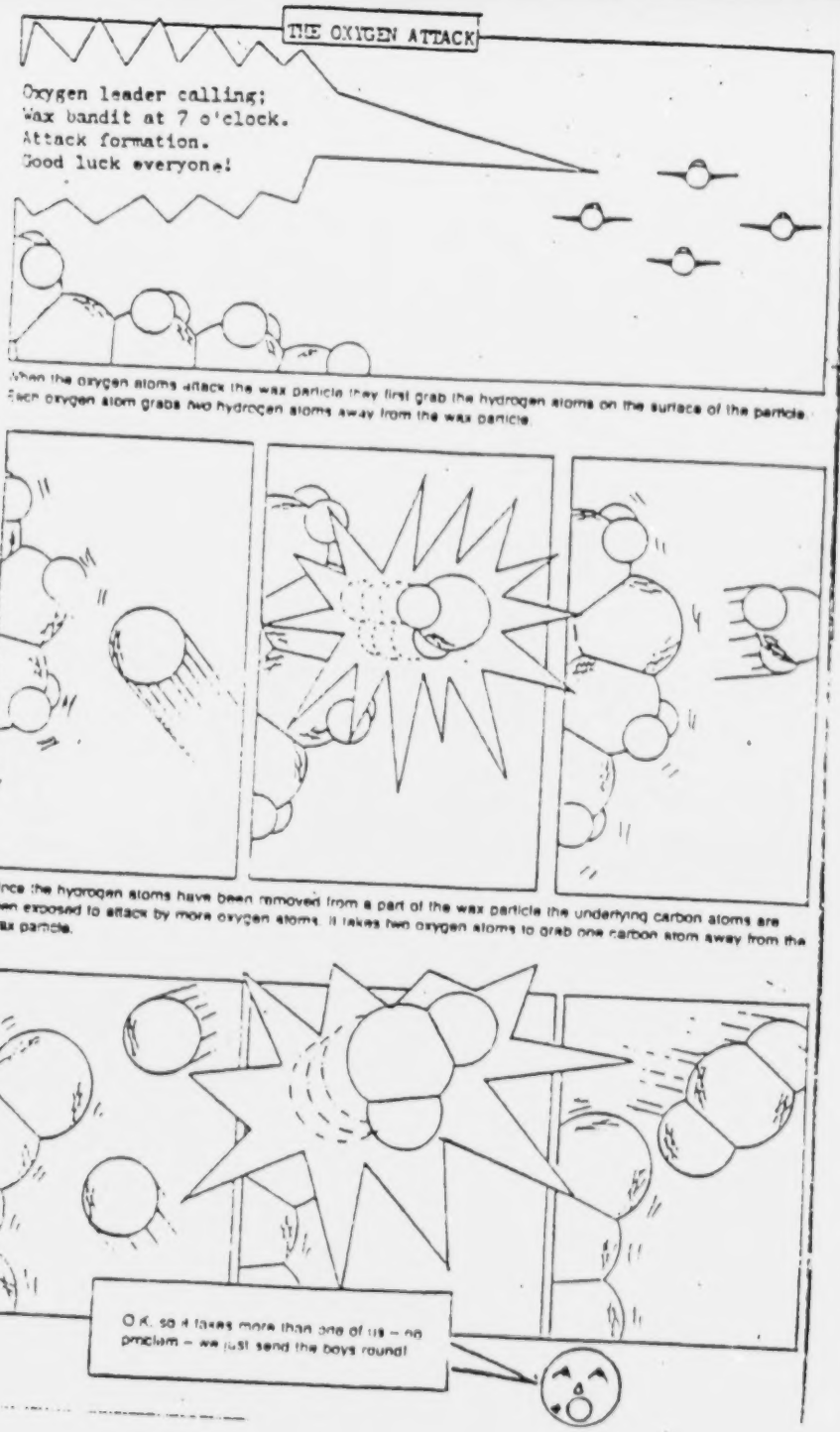
THE OXYGEN ATTACK
Oxygen leader calling;
Wax bandit at 7 o'clock.
Attack formation.
Good luck everyone!
O.K. so it takes more than one of us – no problem – we just send the boys round!

When the oxygen atoms attack the wax particle they first grab the hydrogen atoms on the surface of the particle. Each oxygen atom grabs two hydrogen atoms away from the wax particle.

Once the hydrogen atoms have been removed from a part of the wax particle the underlying carbon atoms are then exposed to attack by more oxygen atoms. It takes two oxygen atoms to grab one carbon atom away from the wax particle.

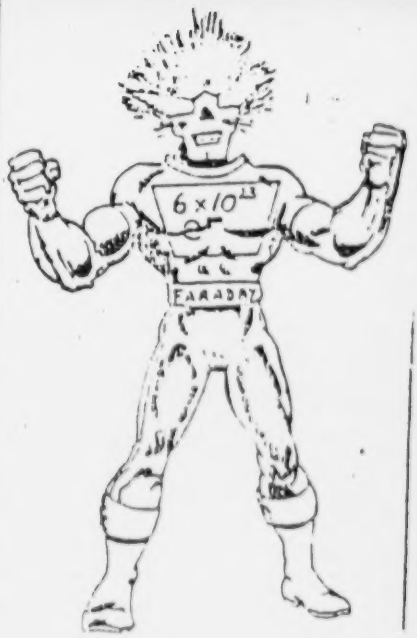

Fig 2.

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understanding of a particular point. This represents 78% of secondary classes involving an explanation which is not in keeping with scientific orthodoxy.

Explanations included things such as:

"Particles in a heated solid vibrate more and more until they 'cannot stand it any longer and they melt".

"The veins of leaves hold them open to the sunlight, 'hoping to be able to start to photosynthesis".

Why teachers use such explanations is clear - they believe it helps children to understand. We feel there is more to it than this. The use of explanation by teachers which involve feeling and emotion is a more - albeit not a deliberate one - away from the objectivity of science. That cannot but be good for women. Why do pupils use such explanations? There may be several reasons, as we have outlined here. A stage in their development. Or perhaps an uncritical use of particular terms with which they have become familiar and use unthinkingly. For us, however, they represent a set of explanations about science that draws on a range of experience which related strongly to the feminist view of science. One in which interconnectedness, not objectivity, human-ness, not mechanistic approaches are the frameworks for examining and explaning phenomena around us. More, not less, of anthropomorphic explanantion will assist women's understanding and assist science itself. Developing such explanatory frameworks with children would seem to be the next step forward in moving towards a feminist view of science.

Ending's weak? I'm afraid I was exhausted! I've [I've also a stressed frog
not played the references - although I have done them seemed a
On the whole not an awful effort, but not my best. marks
Only a few more days! :3 Hurrah! Can't wait
to see you again.
Happy Birthday love you. 19

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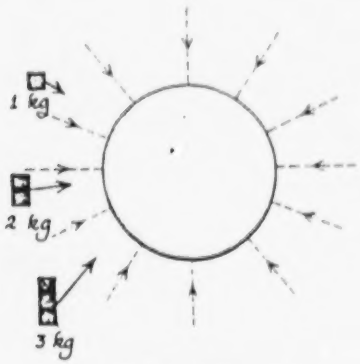
We think of the Earth as ready to pull, even when there is nothing there to pull on. We say the Earth has a GRAVITATIONAL FIELD, like invisible tentacles spreading straight out from the Earth waiting to clutch things. The field is not a force; it is a 'readiness-to-pull'. (When you go to a comic film, you are ready-to-laugh if there's a joke to laugh at.)



earth's gravitational field

Fig 3

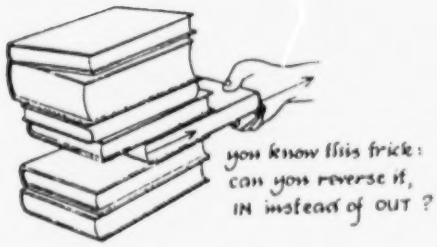


Fig 4

A shorter name for inertia We often say MASS instead of INERTIA. However, we still use the word 'inertia' because it reminds us of laziness. INERTIA is the 'laziness' of matter, and MASS is the measured amount of inertia, measured in kilograms.

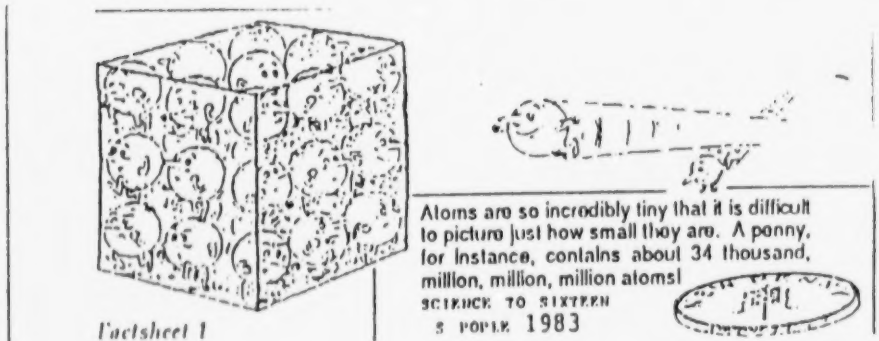

Factsheet 1
Atoms are so incredibly tiny that it is difficult to picture just how small they are. A penny, for instance, contains about 34 thousand, million, million, million atoms!
SCIENCE TO SIXTEEN
5 POPLE 1983

Fig 5

Verbal explanation by teachers are also used. In observing a total of 43 science lessons, involving 43 different teachers, with classes of pupils ranging from 6 to 16 anthropomorphic or animistic explanations were given to children in 36% of them. If the percentage of secondary lessons (12 - 16 years) is calculated separately from those of primary (6 - 11 years), then the percentages are quite different. 14 of the lessons seen were secondary ones. Of these 11 involved an explanation which had an animistic or anthropomorphic base. The explanation was sometimes given to the whole class, or sometimes to a group to aid their

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understanding of a particular point. This represents 78% of secondary classes involving an explanation which is not in keeping with scientific orthodoxy.

Explanations included things such as:

"Particles in a heated solid vibrate more and more until they 'cannot stand it any longer and they melt".

"The veins of leaves hold them open to the sunlight, 'hoping to be able to start to photosynthesis".

Why teachers use such explanations is clear - they believe it helps children to understand. We feel there is more to it than this. The use of explanatiCn by teachers which involve feeling and emotion is a more - albeit not a deliberate one - away from the objectivity of science. That cannot but be good for women. Why do pupils use such explanations? There may be several reasons, as we have outlined here. A stage in their development. Or perhaps an uncritical use of particular terms with which they have become familiar and use unthinkingly. For us, however, they represent a set of explanations about science that draws on a range of experience which related strongly to the feminist view of science. One in which interconnectedness, not objectivity, human-ness, not mechanistic approaches are the frameworks for examining and explaning phenomena around us. More, not less, of anthropomorphic explanantion will assist women's understanding and assist science itself. Developing such explanatory frameworks with children would seem to be the next step forward in moving towards a feminist view of science.

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